Lawrence Livermore National Laboratory

LLNL ASP Project

Global Modeling of Atmospheric Aerosols Including SOA

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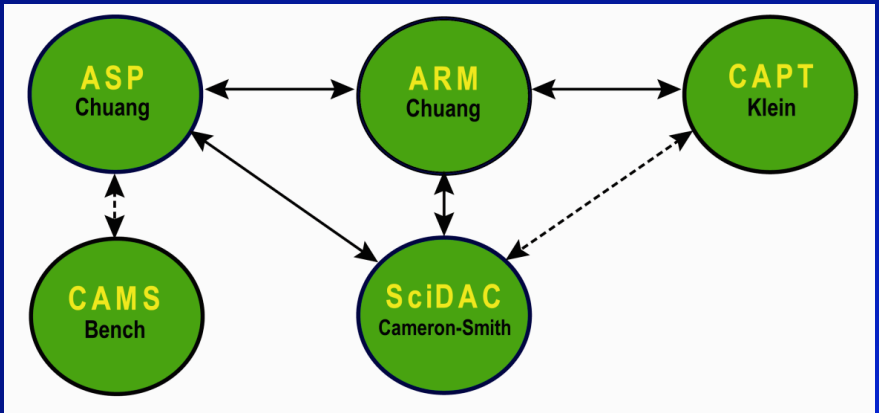
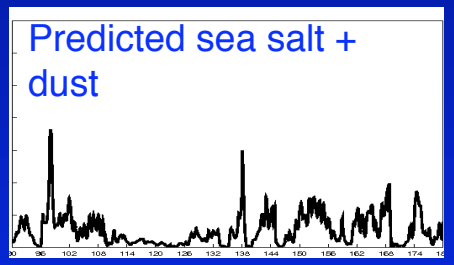
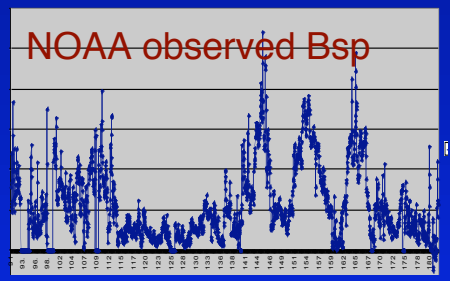
Aerosol related projects and interactions at LLNL



- **ASP**: Global modeling of chemical and physical processes that contribute to aerosol properties
- **ARM**: Examine the sensitivity of aerosol indirect effects on aerosol properties and improve the assessment of aerosol climatic impacts using the **CAPT** framework
- **SciDAC**: Develop a compact chemistry mechanism for earth system modeling
- **CAMS** (Center for Accelerator Mass Spectrometry): Laboratory analysis of aerosol compositions

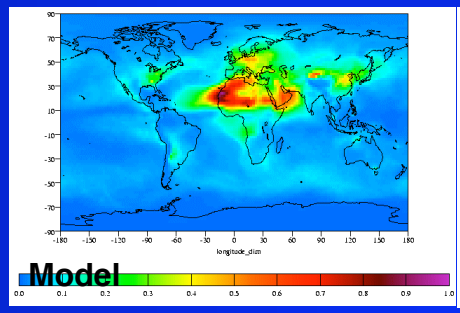
- HTAP (Hemispheric Transport of Air Pollutants)
- AeroCom (Aerosol Inter Comparison)
- ASP-MASE (MArine Stratus Experiment, 2005)

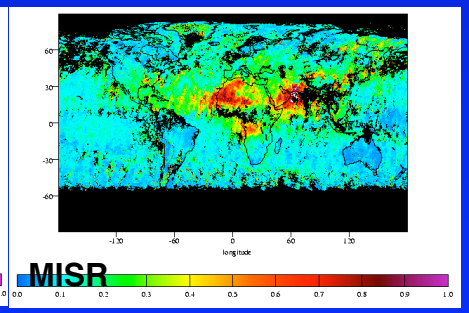




- Validate simulated AOD with satellite data

Monthly averaged AOD, July 2001

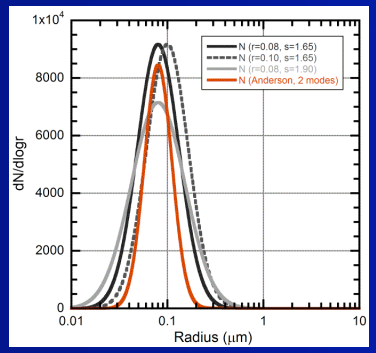


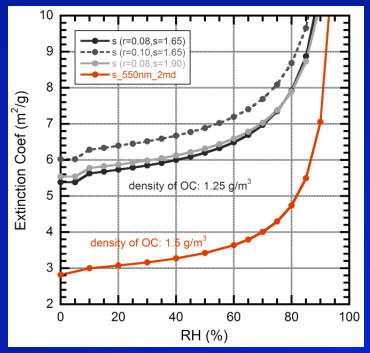


However, SOA mechanism and aerosol micro-physics were not included in our global model!

Size distribution sensitivity

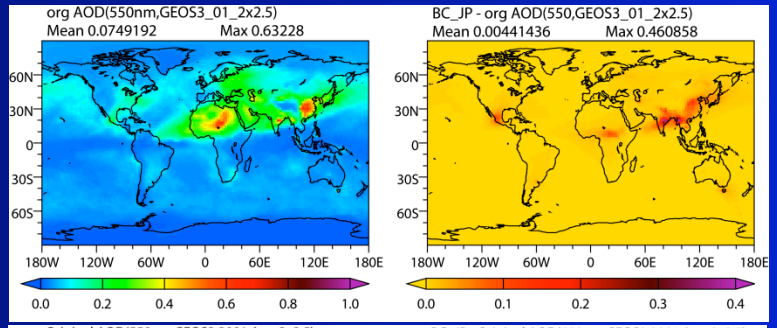
Size distributions and extinction coefficients for biomass burning aerosols



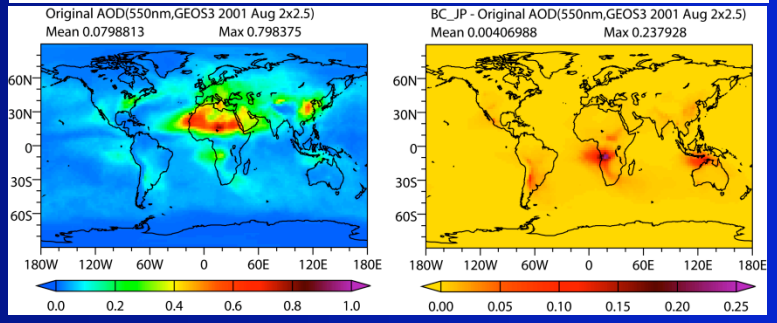


Original and difference of AOD

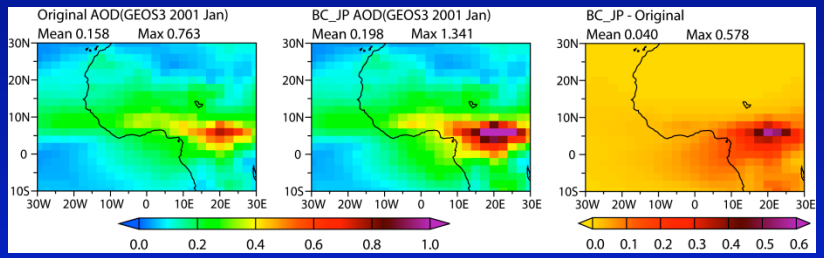
April



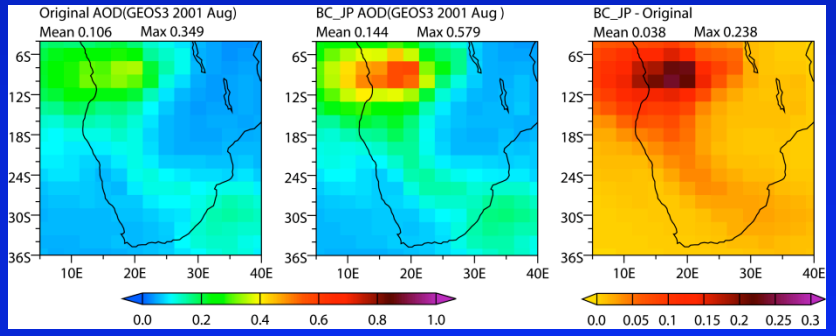
August



Ivory Coast , Jan, AOD changes up to 0.6



S. Africa, Aug, AOD changes up to 65%



- Aerosol microphysics (i.e., size distribution and state of mixing) plays an important role in aerosol radiative forcing.
- Magnitude of forcing uncertainty associated with aerosol microphysics is not well identified.

Enhance our global model (IMPACT) with better representations for SOA formation and aerosol microphysics

Chemistry mechanism:

Tropospheric photochemistry (156 reactions)
Sulfate chemistry (7 reactions)
SOA chemistry (11 reactions) [Pun et al., 2004]
94 reactive and 2 non-reactive gas species

Aerosol microphysics:

MADRID 1 [Zhang et al., 2004]
29 aerosol components
Mass and number concentrations
8 bins (0.02 mm - 10 mm)

Emissions:

Inventory data
EDGAR, RETRO, GFED, GEIA, POET, and AeroCom
Interactive
Dust, Sea Salt, *Biogenic sources (MEGAN)*

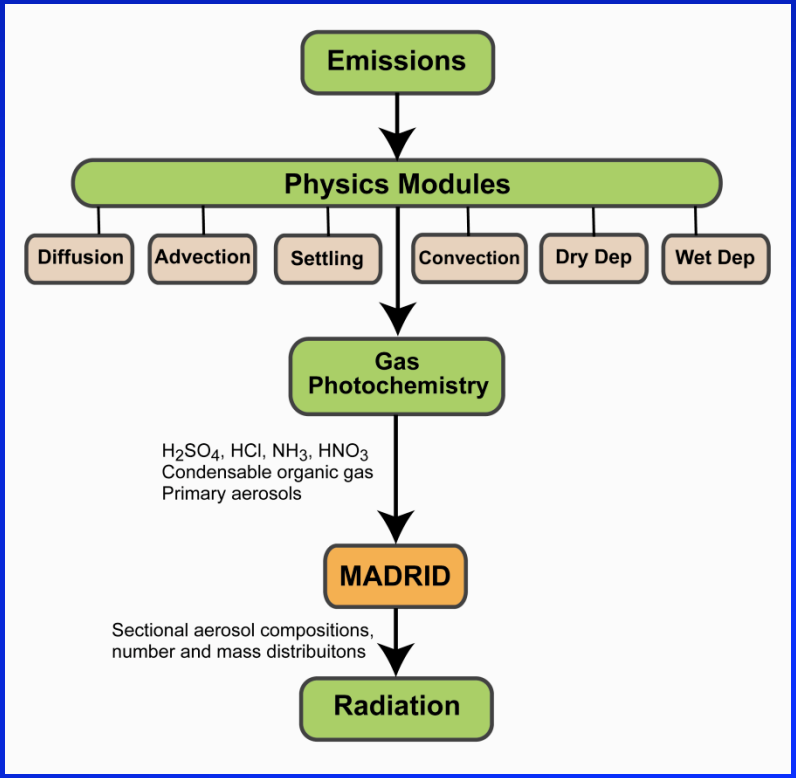
Meteorology :

GCM output
NASA/DAO (assimilated)

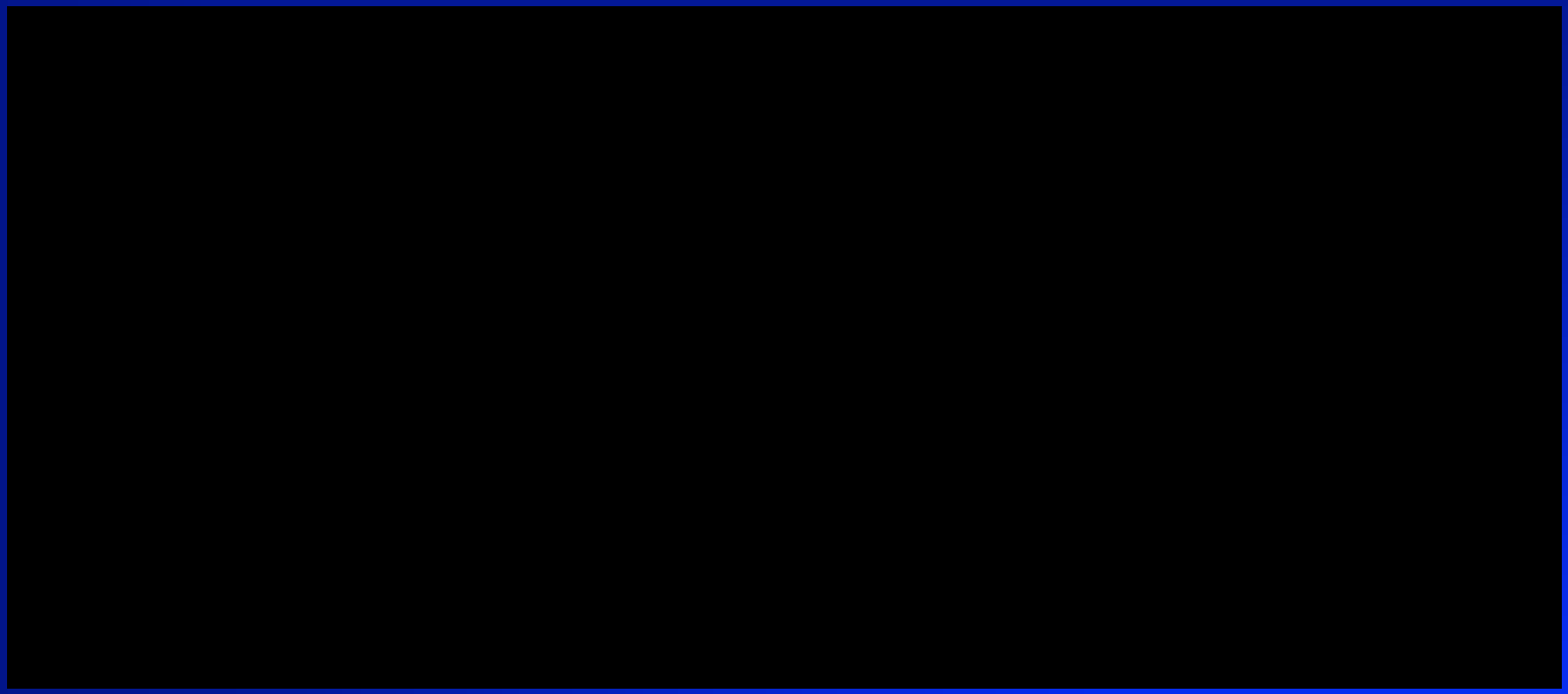
Resolution:

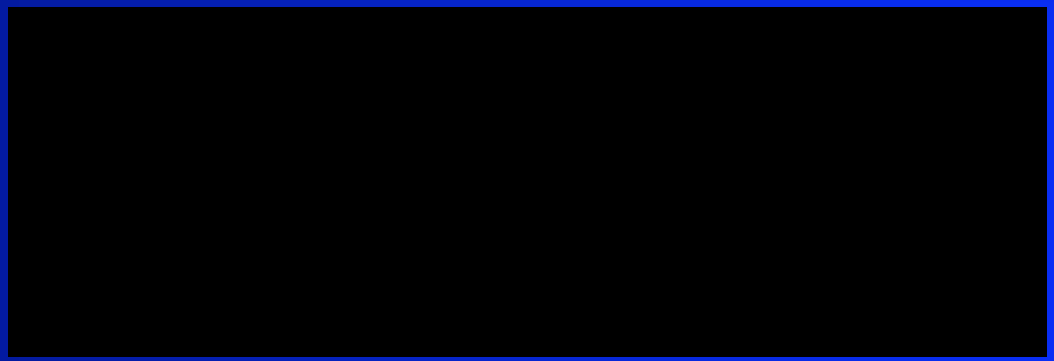
Meteorology dependent
(1°x1.25°, 2°x2.5°, 4°x5°)

New Flow Diagram of IMPACT



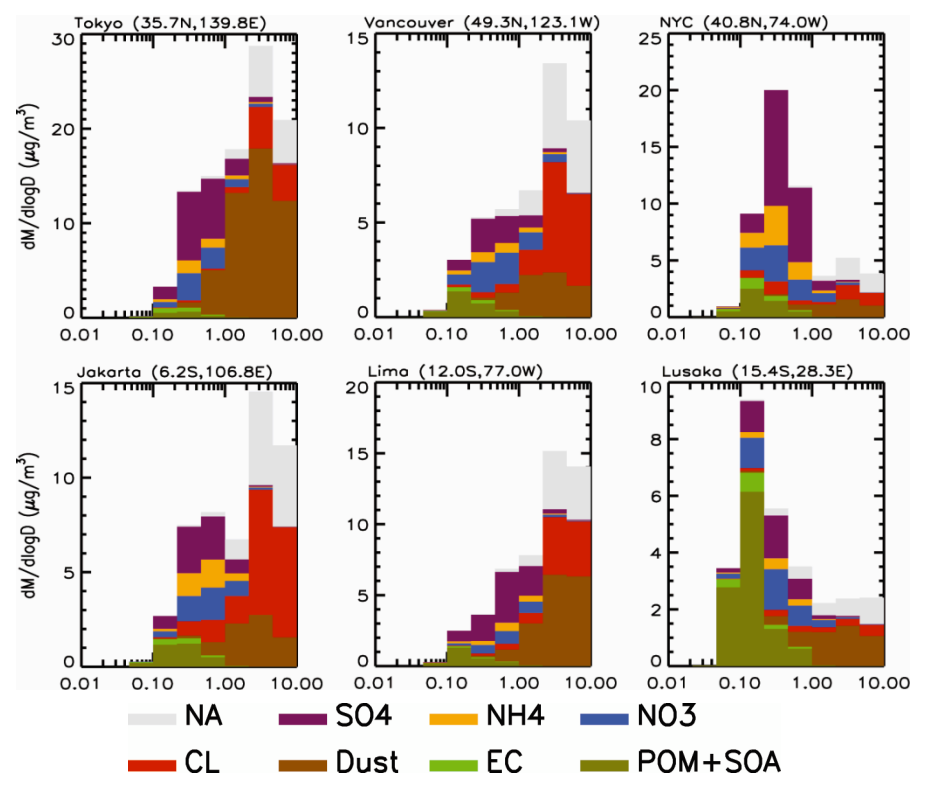
Simulated annual aerosol concentrations for year 2004 in 2°x2.5° resolution





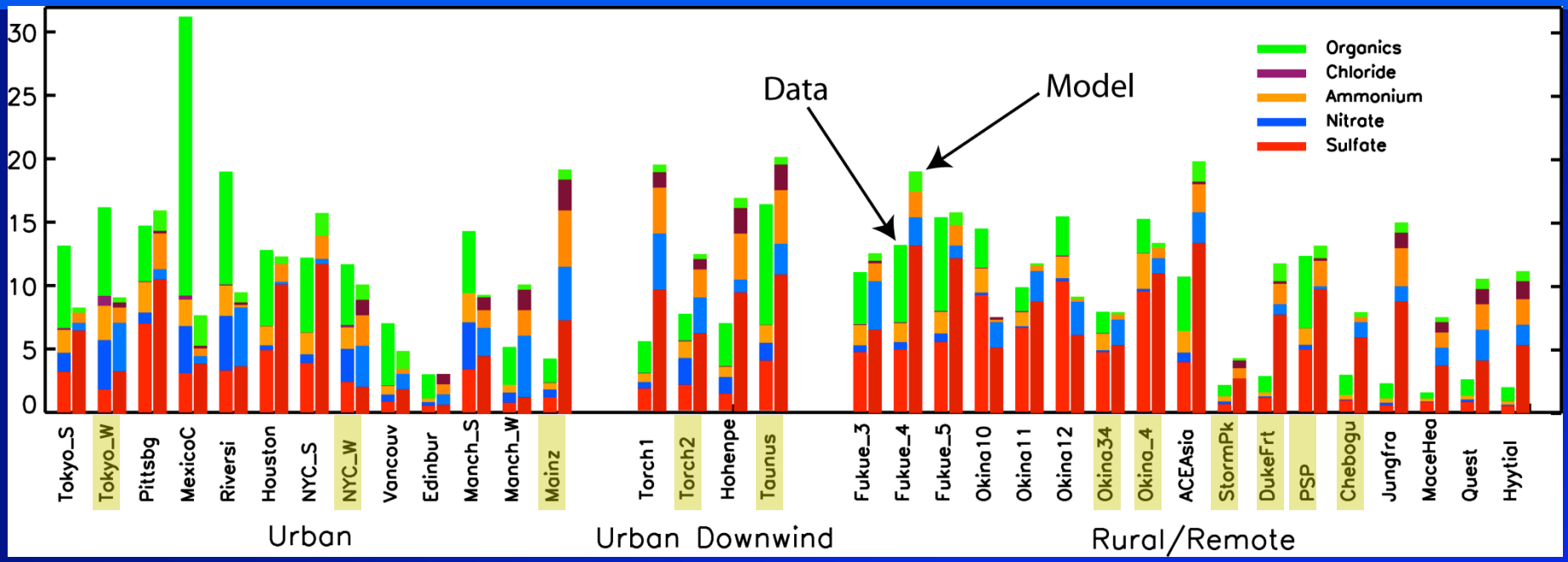
Mass and number size distributions at selected sites

Mass size distributions at surface



Number size distributions at surface

Comparison of simulated PM1 to data from AMS in field campaigns from 2000 to 2006 [Zhang et al., 2007]



Shaded refers to campaigns in 2004

Fundamental issues

- Model results are shown as monthly average, diurnal cycle is not represented.
- Model resolution vs. point measurement

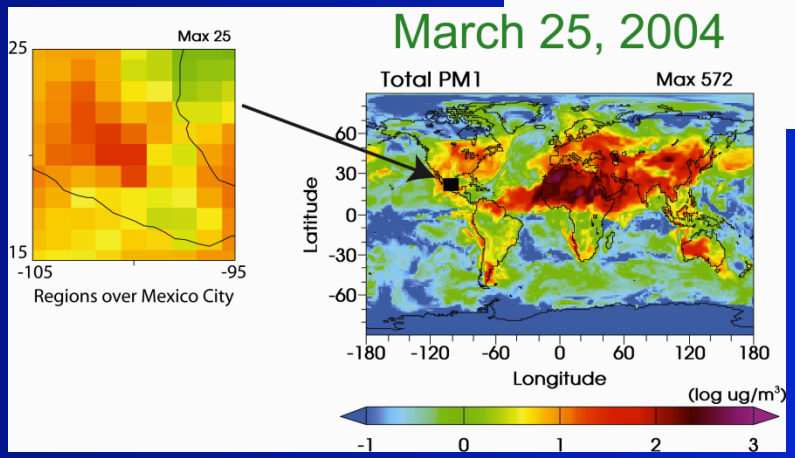
Main findings and possible improvement

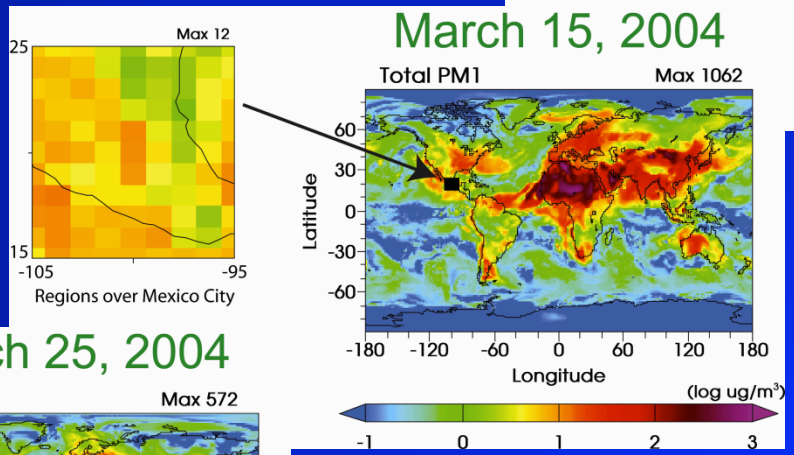
- Simulated OC values are always lower than measurements, specially in urban regions.
  - POM emissions over land may be underestimated.
  - POM sources over ocean are not accounted for.
  - Some SOA formation pathways are not included.
- Simulated SO4 is in a better agreement with data over Asia ad N. America than over Europe.
  - EDGAR2000 has much higher SO2 emissions in Europe than AeroCom.

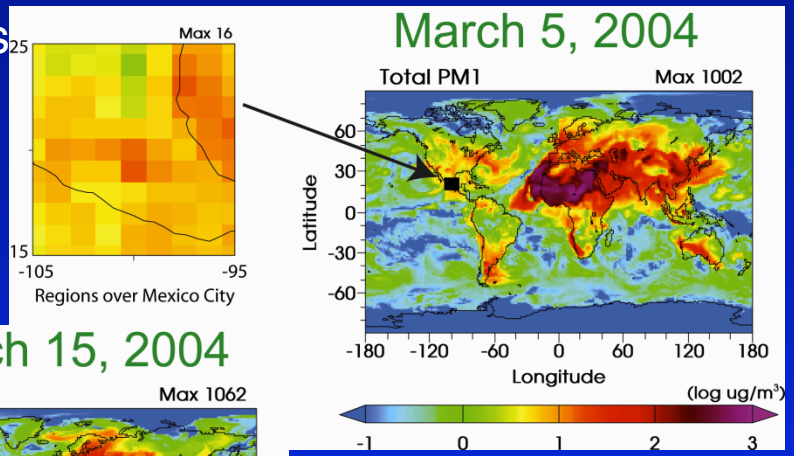
Application of high resolution of IMPACT in field campaigns

- Predict aerosol distributions before field studies (using 5 day forecast meteorology)
- Diagnose aerosol sources and transformation (using the assimilated meteorology)
- Compare to measurements

1°x1.25° global resolution for March 2004







- Catch the detailed movement of dust plume.
- Regions over Mexico City show a significant daily variation of PM1.
- High resolution of global model can serve as the input boundary conditions for regional models.